Canadian Grain Commission | Commission canadienne des grains

Grain Research Laboratory

Annual Report 1989-90

Canada

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GRAIN RESEARCH LABORATORY
63rd Report : 1989 - 1990

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Front Cover

Micro-processing of spaghetti in the Durum Wheat Research section.

GRAIN RESEARCH LABORATORY
1989 - 90 REPORT

May 25, 1990

Canadian Grain Commission
Winnipeg, Manitoba

Commissioners:

I am pleased to submit the following report reviewing the activities of the Grain Research Laboratory for the period April 1, 1989 to March 31,1990.

Respectfully,

K.H. TIPPLES
Director

Director's Comments

This has been another full year for Grain Research Laboratory (GRL) staff, highlighted by the 75th Anniversary Open House in June.

A number of external factors influenced our work during the year, most notably:

- a severe wet harvest in Western Canada in 1989.
- a heavy incidence of fusarium head blight in Eastern Canadian White Winter Wheat.
- changing market patterns for Canadian grain.

The problem of maintaining grain quality in any given crop year is exemplified by problems associated with adverse growing and/or harvesting conditions in Western Canada. Over the long term, one harvest in three sees wet conditions in some areas, resulting in sprout damage plus non-visual germination damage and associated undesirable high levels of alpha-amylase activity. Nineteen eighty-nine was probably the worst year since 1968 for producing elevated levels of enzyme activity in harvested grain and Canada's grading system was pushed to the limit to maintain high and consistent quality in shipments of top grade milling wheat. To this end , the Laboratory was called on to carry out a considerable amount of extra monitoring work on rail carlot and cargo shipment samples.

The workload of the mycology and residue analysis sections was greatly increased by an extensive screening and testing program related to the fusarium head blight problem in Southern Ontario and associated presence of "tombstone" kernels and the mycotoxin deoxynivalenol (DON, or vomitoxin). Collaborative efforts with the Grain Inspection Division and the Ontario Wheat Producers Marketing Board were successful in maintaining export shipments free from objectionable levels of DON.

Market development and support activities were somewhat reduced following markedly lower grain production due to the severe Prairie drought of 1988. However, the Canadian Grain Commission has continued to encourage the Laboratory to give high priority to the Canadian Wheat Board market development programs for soft white spring, red winter and Canada Prairie Spring wheats aimed to develop new or expanded markets, particularly in South East Asia where noodles are the predominant wheat-based product for human consumption. In the last couple of years the United States has become a major purchaser of Canadian wheat, especially amber durum wheat. This has brought forward new challenges related to servicing the unique quality demands of this market.

Stricter government occupational health and safety standards have necessitated increased efforts to ensure safe working conditions. A full-time safety officer is being recruited and a substantial time commitment by all staff is required in order that the GRL can fully comply with Health and Welfare Canada rules and regulations regarding safe storage, handling and disposal of dangerous materials. As well, a comprehensive training program on the new Workplace Hazardous Materials Information System and Management of Dangerous Substances regulations was recently developed and carried out for all staff.

The 1990's will be a critical period for the Canadian grain industry. Notwithstanding the debilitating subsidy wars that have distorted the relation between export grain prices and true technological value, buyers are continuing to demand high and consistent quality. Environmental concerns of food consumers are also putting more pressure on grain processors to demand raw materials that can pass the strictest purity standards.

We look forward to responding to the challenges arising as we continue to play our part in maintaining grain quality and developing new and improved methods for grading and segregating grain.

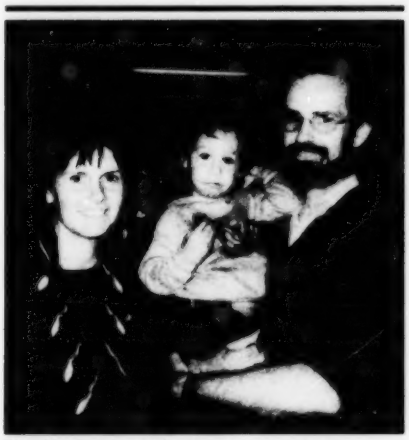
Introduction

As documented in last year's annual report, 1989 was the 75th anniversary of the commencement of operations of the Grain Research Laboratory (GRL). We were pleased to see that one hundred and thirteen of our friends from the grain trade took the opportunity to visit the GRL during an "Open House" held to mark this occasion. We also thank those who wrote to us extending their congratulations on learning of this milestone and hope that the close ties between us will continue.

The Grain Research Laboratory, which functions under Section 12 of the Canada Grain Act (1971), undertakes programs serving one or both of two basic objectives - **quality assurance** and **market support** for Canadian grain. In support of meeting these objectives, effective scientific liaison with national and international bodies was maintained through staff membership and involvement in relevant societies, associations and committees. The director and senior scientists represented Canada and the Canadian Grain Commission at various international meetings to ensure that our interests were equitably served during the development of various new and modified international standard methods for grain quality analysis.

Two achievements attained by GRL staff members should be noted this year. **Janet Panford** obtained the PhD degree from the University of Guelph in Ontario. Dr. Panford was enrolled in the Department of Food Science and the topic of her thesis was "Factors Affecting Wavelength Selection for the Determination of Protein, Oil, Water and Fibre in Oilseeds by Near-infrared Reflectance Spectroscopy". **Dr. J.K. Daun** and **D.R. DeClercq** were honored with an award from the Protein and Co-products Section of the American Oil Chemists' Society. Their research paper titled "Determination of the Total Glucosinolate Content in Canola by Reaction with Thymol and Sulfuric Acid" was judged *Best Paper in 1989*.

Dr. Michael Edney has joined the GRL staff as a feed grains Research Scientist in the Basic Barley Research Section. Dr. Edney, a graduate of Queen's University in Ontario, obtained his PhD degree from the Technical University of Munich and until his appointment was studying at the GRL as a holder of a travelling fellowship from the Natural Sciences and Engineering Research Council of Canada.



Newly-appointed feed grains scientist Dr. Michael Edney, with wife Franziska and son Alexander.

This year's report contains a feature on the history of the development of durum wheat varieties in Canada and the role of the Grain Research Laboratory in the quality testing, assurance and enhancement of this wheat as used for pasta products.

The permanent staff of the GRL totalled 109 at March 31, 1990. In addition, 13 casual assistants were employed for varying periods throughout the year, as well as seven COSEP (career-oriented summer employment program) students.

Apology. We wish to apologize to **Dr. Martin Scanlon** for the fact that his name was inadvertently omitted from the list of Post-Doctoral Fellows which appeared in the GRL Annual Report for 1988-89. Dr. Scanlon undertook his post-doctoral studies at the GRL in 1985-86 and has recently joined the Flour Milling and Baking Research Association in Chorleywood, England.

75th Anniversary Open House

The following scenes are typical of the activities which took place during the Open House held to commemorate the 75th anniversary of the Grain Research Laboratory.

Conventional and electron microscopy photographs

Specially designed and constructed visual aids and displays.

Setting up

Exhibit of information on restricted weed seeds.

"On site" visitors at several Laboratory sections.

Mycology

Falling Number testing

Durum wheat research

And what would an "Open House" be without refreshments.....

....and camaraderie?

Letters

June 20, 1989

Dr. W. Seibel,
Director

Institute for Baking Technology
Detmold, Federal Republic of
Germany

Dear Dr. Tipples:

I have just read your "historical" report with the five pictures of past GRL directors on the front cover. You do realize that except for Dr. F.J. Birchard, I know or knew all these experts personally. I have also read with great interest the "stories" which demonstrate the spirit of these 75 years.

Congratulations on your 75th anniversary and also for that excellent issue.

Best regards

July 26, 1989

Dr. E. Gebhardt
National Delegate

International Association for Cereal
Science and Technology
German Democratic Republic

Dear Dr. Tipples:

I am pleased to note that this year the Grain Research Laboratory celebrates its 75th anniversary.

Passing in review are 75 years of scientific progress as a result of daily activities in commercial production areas, trade and grain processing in your country and all over the world. I wish you and your staff further enthusiasm and success.
I do hope that the relations between our countries, as well as the cooperation within the ICC, will continue to be progressive and successful.

Kind regards.

Sincerely yours

July 25, 1989

Dr. Alfredo Salazar Zazueta
Director of Research

Laboratorios de Calidad
Chapingo, Mexico

Dr. K.H. Tipples:

We are pleased to extend to all of you our *congratulaciones* for 75 years of achievements and hard work for the advancement of knowledge on grain quality.

The technical and scientific basis of our grain research laboratories (CEREALS, OILSEEDS AND LEGUMES) of the National Institute for Agricultural Research of Mexico also derives from the outstanding work you have done. We all take a personal pride in knowing the GRL through either your publications or visits.

Felicidales!

August 16, 1989

T. G. Atkinson
Director

Research Station, Agriculture Canada
Winnipeg, Canada

Dr. K. Tipples:

On behalf of the staff of the Winnipeg Research Station, I would like to congratulate you and your staff on the occasion of the 75th anniversary of the Grain Research Laboratory.

The knowledge and expertise in applied and basic cereal quality, developed and delivered by the GRL over its 75 year history, has been paramount in establishing and maintaining Canada's unrivaled reputation for consistent quality assurance in the grain trade.

Research Station cereal chemists, breeders and mycotoxicologist have been pleased to collaborate and consult with your staff in problem solving and research of mutual interest and concern and we look forward to continued or increased opportunities to do so.

Again, best wishes on your 75th anniversary and congratulations on a job well done!

Yours sincerely

June 28, 1989

Dr. hab. J.R. Warchelewski
GRL Post-Doctoral Fellow 1972

Academy of Agriculture
Poznan, Poland

Dr. K.H. Tipples:

A TRIBUTE TO THE GENERATIONS OF GRL STAFF

On the arrival of the GRL 1988/89 Report, I realized that the Grain Research Laboratory had already celebrated its 75th anniversary. As a member of the GRL family in the years 1972-73, I would like to extend to you and your colleagues (some of you my friends) my best sincere congratulations for a job well done. Through these 75 years, the generations of GRL staff have built a world-wide reputation both by outstanding research activities as well as by the excellence of the Laboratory staff. It was my privilege indeed to be able to spend a year in the GRL and consequently to contribute to the 75-year history of the Laboratory.

Best wishes for continued success in your endeavor to discover the truth enclosed in a tiny, single kernel.

Sincerely yours

Dr. Simo Jelaca
Scientific Advisor

SACEN Center
Novi Sad, Yugoslavia

June 12, 1989

Dear Dr. Tipples,

My sincere congratulations to the previous and current staff members of the Grain Research Laboratory on your 75th Anniversary - for world wide valuable contributions in cereal science.

Personal congratulations also to you Dr. Tipples on your 10-year anniversary of being the successful director of such a successful scientific institution.

My life's happiness was to be one of your Post-Doctoral Fellows (1968 to 1970), during which time I built-up very good friendships with most of you.

On my leaving Winnipeg, the unforgettable late Dr. Hlynka had announced that I would be acting as the Yugo-Canadian Ambassador between nations, which I will be doing with pride for my entire life. As well as the PhD degree, I brought from Canada the loveliest souvenir and strongest link between us - our first daughter, born in Winnipeg as a Canadian citizen.

Some of you (the late Dr. Hlynka, Dr. and Mrs. G.N. Irvine, Dr. and Mrs. W. Bushuk - twice, Dr. and Mrs. R. Tkachuk) have already visited Yugoslavia. We'll be glad to welcome you all; so please remember that our hearts are opened for everyone from the GRL.

Sincere regards and best wishes to all of you.

Sincerely yours

Objectives and Operations of the GRL

The Grain Research Laboratory has a mandate, under the Canada Grain Act (1971), to undertake research into grain and grain products. Generally, this research and its associated functions address one or both of the major objectives of **quality assurance** and **market support** for Canadian grain.

Quality assurance work has several aspects. *Monitoring of cargoes and carlots* of grains and oilseeds includes surveys of the average quality of Canadian grain exports and screening to ensure that Canadian grain is free of toxic substances such as pesticide residues and mycotoxins. *Quality evaluation of experimental lines* for possible registration is performed in collaboration with Canadian plant breeders. *Technical and scientific support* for the Canadian Grain Commission's Grain Inspection Division requires calibration and monitoring of instruments currently used for operational testing of grain moisture and protein content, development of new and rapid instrumental methods of grain analysis and research studies into the effects of various damage factors such as frost, immaturity and sprouting on end-use quality.

Market support activities involve the provision of technical expertise and advice to agencies such as the Canadian Wheat Board and the Canola Council of Canada both in marketing the different grades of newly-harvested material and in developing new markets for existing and new classes of Canadian grain. This type of work includes: *travel to overseas markets* to determine the grain processing methodology used in those countries; *research at the GRL* to simulate the observed processing methods and determine the suitability of different grades and classes of Canadian grain for specific end-products; *travel to existing and potential market countries* to guide and discuss commercial-scale milling of various classes of Canadian wheat; and *provision of expert information and advice* on the end-use quality characteristics of different grades of Canadian grain.

The many programs which comprise GRL operations may be broadly categorized as research, related scientific activity or the provision of scientific and technical expertise - all of which are interrelated. *Research* is necessary to enable us to better define *quality* and develop new and improved methods of measuring it. *Related scientific activities* embody such programs as harvest surveys, cargo and carlot monitoring and cultivar evaluation. *Scientific and technical expertise* is essential if we are to provide appropriate advice to the Canadian Grain Commission and support for the Commission's Grain Inspection Division.

Summaries of these activities for 1989-90 are provided in the Quality Assurance, Market Support and Research sections which now follow.

Quality Assurance Activities

Cargo and Carlot Monitoring

All export shipments of wheat, barley, oats, rye, canola, corn, and soybeans, involving 1,180 cargoes for the 1988-89 crop year, were screened to confirm freedom from contamination by organochlorine, organophosphate and organonitrogen pesticide residues. Selected cargo shipments of wheat and barley were also monitored for the presence of phosphine and toxic elements. Screening for the presence of diquat in lentils was instituted and involved testing of 72 container shipments. A total of 195 shipments of wheat, barley, corn and soybeans were screened for mycotoxins.

In order to determine the existence of any potential hazards associated with fusarium head blight infections in wheat grown in Ontario in 1989, extensive monitoring for *Fusarium* trichothecene toxins was carried out. The 403 samples screened included infected wheat heads, harvest samples, transfer elevator delivery composites, bulk vessel loadings and truck, rail and container export shipments. Samples of Quebec-grown wheat were also tested as part of these quality assurance initiatives.

Because of wet harvesting conditions in many parts of the Canadian Prairies in 1989, an extensive carlot monitoring program was instituted for Canada Western Red Spring (CWRS) and Canada Western Amber Durum (CWAD) wheat. This entailed sampling every tenth car of CWRS and CWAD wheat moving through the grain transportation system and using the Falling Number test to check the sample for sprout damage. This allowed identification of locations from which originated wheat of high alpha-amylase activity, and determination of the variability in alpha-amylase levels that could be expected in the various grades of wheat.

Samples of 139 cargoes (1.94 million tonnes) of canola were monitored for oil and protein content, fatty acid composition, free fatty acids, glucosinolates and chlorophyll level.

The weed seed monitoring program initiated last year was continued, and involved analysis of every grain shipment to certain destinations.

Technical Services

The Grain Research Laboratory is responsible for the maintenance of moisture meters used at the Canadian Grain Commission (CGC) during official grading of grain. This work has two aspects: production and verification of conversion tables used for the Model 919/3.5 meter; and maintaining the accuracy of all Canadian Grain Commission moisture meters. For converting meter reading to an estimate of actual moisture content, separate calibration equations must be developed for each type of grain; and since the relationship between meter reading and moisture content is influenced by factors such as variety, seed size and density, these calibrations must be continually checked for validity and updated as necessary.

There are currently 29 conversion tables (generated using the appropriate calibration equations) for 25 types and classes of grain. Effective July 1989, two updated conversion tables for use with the Model 919/3.5 meter were issued for Eastern Canadian corn. One table, No.10A, is used to convert the 919 dial reading and grain temperature to a percent moisture content - while the second table, No.10B, is used to correct the moisture content obtained from Table 10A for test weight.

Moisture meters used in CGC offices are monitored for accuracy and precision through a biweekly check test. Meters not functioning satisfactorily are recalled to the GRL for servicing and electronic alignment.

The GRL provides confirmatory services to the Grain Inspection Division of the CGC for grain samples suspected of contamination by seed treatment chemicals. On submission by the grain inspector, carlot samples are analyzed for toxic residues and a report prepared. A total of 151 samples were tested in the crop year ending July 31, 1989 - with action being taken against 23 carlots.

The GRL also provides definitive varietal identification based on protein fingerprinting for wheat and barley samples submitted by the Grain Inspection Division. In the 1988-89 crop year, 94 cargo, carlot and miscellaneous samples (5,752 individual kernel analyses) were tested.

Other technical services performed include quality testing of samples submitted by various segments of the Canadian grain industry through the Grain Inspection division of the CGC. Examples are: testing wheat for possible quality damage due to improper use of artificial drying, testing for alpha-amylase activity and testing malting barley for germination energy.

Grading Factor Studies

Wheats of various classes and grades were fractionated on commercial scale specific gravity tables. Laboratory analysis showed that fractions from the lower grades in particular exhibited wide ranges of quality - due mainly to segregation of the wheat according to kernel size and type of damage (sprouted, tombstone, immature/thin). These results should be of interest to the wheat industry (particularly when adverse growing and harvesting conditions result in a high proportion of the crop being of low grade) since this technique offers a practical, simple and economical means of improving the grade and quality of some grain parcels. Application of this method should also be possible for other grains such as malting barley, milling oats and canola.

In analyzing samples of Canada Eastern White Winter wheat from various points in the delivery and shipment system for vomitoxin (deoxynivalenol or DON), a high correlation with percent *tombstone* kernels was obtained. This confirms the validity of controlling DON levels in cargo exports through enforcement of a *tombstone* kernel grade tolerance in deliveries into the licensed elevator system.

Two near-infrared transmittance (NIT) spectroscopy instruments (Trebor GT-90, Tecatur Infratec 1225) were evaluated for determining the moisture content of high moisture corn. In comparisons with the 3-day oven reference procedure, results were encouraging - a correlation coefficient of 0.98 was obtained in analysis of data from the Infratec instrument. Calibration constants for moisture determination in other grains (soft white wheat, oats, soybeans, pea beans, red kidney beans) were developed for the Trebor GT-90. Calibrations were also determined for the Tecatur Infratec 1225 and the DICKEY-john NIR instruments for the analysis of protein, moisture and oil in soybeans.

A project has been initiated in an attempt to distinguish, by chemical analysis, between the seeds of different species of wild sunflower. The seeds of wild common sunflower (*Helianthus annuus*) and prairie sunflower (*Helianthus petriolaris*) are nearly identical morphologically, but only *Helianthus petriolaris* is a restricted weed seed in grain imported by some countries. Seed obtained from samples collected in southwestern Manitoba in September is being analyzed by an electrophoretic procedure and by examining visual characteristics to ascertain whether a chemical identification procedure is practical.

Isolates of the fungi *Alternaria*, *Cladosporium*, *Epicoccum* and *Helminthosporium*, which are commonly found on barley kernels, contain enzymes that solubilize barley beta-glucan. However, no significant levels of alpha-amylase were detected in any of these isolates or in two bacterial cultures also isolated from barley kernels. It appears unlikely, therefore, that normal field fungi contribute to the alpha-amylase levels present in sprouted kernels of barley.

The effect of weathering on canola was investigated using seeds designated by the Grain Inspection Division of the CGC as rimed (discolored). Even lightly rimed seed exhibited significant changes in quality such as: conductivity increase (suggesting a seed coat more permeable to moisture); increased free fatty acid and lowered glucosinolate levels (suggesting hydrolytic enzyme action within the seeds); higher chlorophyll concentrations and lower density (indicating immature seeds).

Cultivar Evaluation

Because of the strain put on GRL resources (as detailed in last year's annual report) in the quality evaluation of potential new wheat varieties, testing of breeder lines has been streamlined - while maintaining confidence in the assessments provided. The GRL continued as a collaborator in the USA Spring Wheat Variety Evaluation Tests.

The Grain Research Laboratory also continued to provide essential quality evaluation support for Canadian malting barley variety development programs. After three years at the Cooperative Test stage and two years of pilot-scale malting and brewing trials in the Collaborative Test, two selections (the six-rowed, blue-aleuroned BT495 and the two-rowed TR226 suitable for the eastern Prairies) displayed sufficient promise to be granted interim registration for commercial, plant-scale testing.

Additional testing indicated that Canadian malting barley cultivars compared very favorably with commercial samples of malting barley from the USA, Australia and France.

Market Support Activities

Harvest and Cargo Surveys

Surveys of the average quality of different grades of the various classes of Canadian grains and oilseeds harvested each growing season continue to be a major endeavor of the Grain Research Laboratory. All surveys were successfully completed in time to present reports at meetings of the Eastern and Western Grain Standards Committees of the Canadian Grain Commission, at meetings held between the Canadian Grain Commission and grain industry groups and associations in Eastern Canada and at meetings and discussions held during Canadian Grain Commission market support visits to Japan.

Crop bulletins providing detailed results of quality tests from this year's harvest surveys were published and distributed internationally for wheat, canola, flaxseed and soybeans. Two new bulletins, one on feed barley and the other on malting barley, were also produced. These publications allow for meaningful dialogue with current and potential customers of Canadian grain on topics relating to the quality parameters normally associated with these grains and oilseeds.

Quality testing of cargo composite samples remains a high priority and the following cargo bulletins documenting the high quality of Canadian grain exports were published and distributed to interested parties throughout the world: *quarterly editions* for red spring wheat, *semi-annual editions* for amber durum wheat and an *annual edition* for canola and flaxseed.

A *semi-annual analysis* of composite samples of the following wheat classes was also continued: Canada Western Red Winter, Canada Prairie Spring, Canada Western Soft White Spring, Canada Western Utility and Canada Eastern White Winter. In addition, a *monthly analysis* of canola cargo composites was completed.

Technical Consultations, Missions and Studies

The director and several GRL scientists participated in a number of missions and consultations at the request of the Canadian Wheat Board (CWB). Visits were made to Colombia, Japan, Korea, the Middle East, Taiwan, the USA and Venezuela. Many of these visits required the presentation of lectures and seminars on the quality of Canadian grain and, in particular, on the characteristics of the just-harvested crop. For example, Dr. Tipples travelled to Tokyo, Japan in November for discussions with government and industry representatives on the quality of the Canadian wheat and canola crops. Dr. Preston was part of a CWB market development and sales initiative in the Middle East to promote the advantages of the Canadian Prairie Spring class of wheat.

Cooperation between the GRL and the Canadian International Grains Institute (CIGI) continued in many of CIGI's market support courses. Numerous tours, lectures, seminars and practical laboratory demonstrations were organized and presented, and a joint study into the effects of flour quality, processing conditions and formulation on the production of Thailand-style bread was undertaken.

Breadmaking research into the effects of ascorbic acid and sodium stearoyl-2-lactylate on Brazilian type bread showed that decreases in loaf volume resulting from removal of ascorbic acid from the formula were attributable mainly to a lack of oven spring. Design and construction of a loaf height tracker used in conjunction with a heat sink oven led to successful completion of this work.

It is of great benefit to understand and evaluate flour components that are important for production of various end-products traditional in non-Western Hemisphere locations. During the past year, a survey of the color of Cantonese noodles prepared with "Kansui" alkali was carried out using a large number of plant breeders' lines of wheat in the Parkland, Western, Central and HY (High Yield) field trials. Certain lines exhibited a definite brown color in the noodle, which thus far has been attributed to the presence of higher levels of the enzyme polyphenol oxidase. To date, the highest activities of this enzyme have been detected in HY samples.

Research Activities

Wheat

The study of wheat proteins and their relationship to quality continued to be a major research priority. High-performance liquid chromatography and SDS (sodium dodecyl sulphate) gradient gel electrophoresis also continued to be the techniques of choice for the study of the gliadin and glutenin proteins. These procedures were used to gain further information about the effects of sprouting on the wheat storage proteins and how these are related to adverse quality changes. Such information will ultimately help to develop superior quality prediction methods as well as provide useful input to plant breeders in their efforts to develop new wheat varieties with tailor-made quality characteristics.

Gluten extractability studies were undertaken to learn more about the gluten proteins known to be associated with breadmaking quality in wheat. Two of the main findings were that a surprising amount of gluten can be extracted with water and that high molecular weight subunits differ in their solubility - that is , subunits 10, 9 and 7 are very soluble whereas subunits 5 and 2 require propanol for resuspension.

In a fertilizer-effect experiment, six wheat varieties were grown at two or three locations over three years at seven rates of fertilizer application. Quality analysis showed that differences between varieties were consistent (similar ranking) in all treatments and that treatments had significant effects on quality parameters.

A versatile small-scale pilot mill was developed by joining two Buhler mills in tandem. A commercially-relevant estimate of common wheat milling potential was achieved using a millflow comprising five break passages, a sizing passage and six reductions. Highly reproducible results were obtained on samples as small as 2 kg, and samples of 100 kg or more were milled easily in one day.

A study into the effect of environment on the relative amounts of different storage proteins in wheat indicates that although there is a small environmental effect, it is not large enough to cause problems in the varietal identification of wheat cultivars when reversed-phase high performance liquid chromatography is used.

A comparison of sensory and instrumental methods for assessing textural characteristics of cooked spaghetti has been completed. Results showed that instrumental values could be used to predict the sensory quality of spaghetti. Nearing completion is an experiment on the effects of protein level and drying temperature on the textural optimization of spaghetti. Seven protein levels (12% to 18%) and five drying temperatures (40° to 90°C) were used. Another project underway involves analysis, by response surface methodology, of blends of durum wheat semolina and hard red spring wheat farina which have been dried at five different temperatures.

Barley and Feed Grains

The polysaccharide beta-glucan is a major cause of problems encountered in malting and brewing, as well as in the feeding of poultry. These problems may be attributed to the structure of the beta-glucan molecule which contributes to its distinct properties. Because of its importance, experiments were initiated to more fully characterize the structure of beta-glucan in barley varieties and to better relate this to end-use quality.

Barley variety identification work using the PhastSystem (registered trade name) has shown that cultivars that can be distinguished by conventional SDS gradient polyacrylamide gel electrophoresis can generally also be distinguished with the PhastSystem (which has the advantage of speed, convenience and safety). Unfortunately, as with conventional techniques, a number of varieties have identical protein patterns and cannot be distinguished one from another. Differentiation of some closely related varieties may be achieved by using the PhastSystem for rapid analysis of enzymes such as peroxidases.

Computer-generated molecular graphics were used to identify functionally important amino acid residues in the two major alpha-amylase enzyme forms present in malted barley. This information helps to explain observed differences in the action of these two components in

hydrolysis of starch and starch-degradation products during malting and brewing.

Two commercially available samples of oat bran were examined by several microscopy techniques and analyzed for various components. Significant differences were detected. For example, the sample which had higher levels of fiber (soluble and insoluble), protein and beta-glucan contained less starch. This suggests that one sample was rolled oat groats and not oat bran, and that there may be wide variation in the composition of products labelled *oat bran*.

Preliminary results from a mycology study into the effects of natural and artificial weathering on barley and wheat samples indicate that the incidence of *Fusarium sporotrichioides* (a species capable of producing a number of mycotoxins) increases as the length of time that kernel moisture is above 25% increases. Samples that were cut and subsequently windrowed appeared to be invaded to a greater degree than did samples that were straight combined.

Oilseeds

Again this year, significant resources were expended on studies of chlorophyll in canola. Spectrophotometric analysis of samples of refined, bleached and hardened canola oils revealed that the absorption maximum shifted from 665 nanometers (nm) in crude and degummed oils to about 654 nm after processing. This is likely due to either conversion of chlorophyll pigments and/or preferential extraction of the pigments causing the absorption at 665 nm. This spectral shift may also explain some of the difficulties encountered by commercial laboratories attempting to determine chlorophyll, in fully refined oils, using automated equipment calibrated for an absorption maximum of 665 nm.

In tests for residual chlorophyll content in meal samples from Western Canadian crushing plants, levels ranged from 1 to 13 parts per million (ppm) with a mean of 5 ppm. This appears to indicate that not all the chlorophyll is extracted with the oil during processing since the chlorophyll levels in the corresponding pre-crushed seed samples ranged from 0 to 61 ppm with a mean of 23 ppm. However, no significant correlation was obtained between seed chlorophyll and residual meal chlorophyll - even when data for each crushing plant were analyzed separately.

Western Canadian crushing plants reported unusually high levels of free fatty acids in the 1989 canola crop. Analysis showed that levels in samples from central and northern Alberta were higher than for samples from other parts of the Prairies. These higher-than-usual levels may be at least partially due to the heavy rainfall which delayed harvesting in these regions. Free fatty acid concentration rose from a mean of 0.3% for the 1988-89 crop year (August 1,1988 to July 31, 1989) to a monthly mean of 1.1% for December, 1989.

High performance liquid chromatography was applied in the glucosinolate analysis of several different varieties of flaxseed. Amounts in the order of 1 to 3 micromoles/g of sinigrin and sinalbin were detected in two samples - possibly due to the presence of *Brassica* weed seeds.

An image analysis technique for rapidly estimating the seed size and shape distribution in canola was developed and applied to plant breeders' samples from Cooperative Test series. Considerable variability in seed size was observed between different cultivars in both *Brassica napus* and *Brassica campestris* species, while more variability in seed shape was evident in *Brassica campestris* lines. Analysis by cultivar and by growing region showed no significant correlations between seed size and oil content, protein content and seed density.

Analytical Methodology

An analytical method employing automated gel permeation chromatography in the sample preparation phase and gas chromatography (GC)- mass selective detection (MSD) in the determinative phase was developed for measuring diquat in lentils. A second GC-MSD apparatus and a high performance liquid chromatography (HPLC) system with a post-column reactor will be used to further develop state-of-the-art methods for detection of toxic substances in grains. Plans for the HPLC system include development of capability for glyphosate analysis.

A method was devised for the measurement of the textural properties of *Kansui* noodles by use of the *Instron* apparatus. The force required to compress noodles to 40% of their original thickness was determined. Significant differences were evident between noodles prepared from Canada Western Red Winter and Canada Western Soft White Spring wheat flours and between noodles prepared with varying concentrations of salt.

In a chlorophyll determination study, results from an international, round-robin, collaborative test involving 22 laboratories suggested that an acceptable inter-laboratory precision was possible using an extraction procedure. The method was forwarded to the Secretariat of Technical Committee 34 of the International Standards Organization for publication as a Draft International Standard.

The determination of wheat kernel hardness by grinding/sieving or NIR methods involves grinding by a procedure which gives a ground meal with a consistent particle size distribution. This is not always practical to achieve. The Tecatur Infratec Model 1225, a near-infrared transmission whole-grain instrument for which sample grinding is not necessary, was evaluated and found to satisfactorily predict wheat kernel hardness. Calibrations were developed for two Infratec monochromaters, and were transferable between instruments.

Durum Wheat

The Grain Research Laboratory's Role in Quality Enhancement and Quality Assurance

The first reference to durum wheat cultivation in Canada is to "Goose" wheat, reported to have been grown in Eastern Canada between 1820 and 1860 (Dickinson, 1979). Another designation was "Wild Goose", described as a durum variety grown "successfully in parts of the Northwest and Canada" (Hunt, 1910). According to the *Dictionary of Spring Wheat Varieties* (1933): "Goose durum is not a true variety but is usually applied to any large kernelled lot durum. Peliss, Kahla and Arnautka durum and Polish wheat are four varieties for which the name Goose is used."

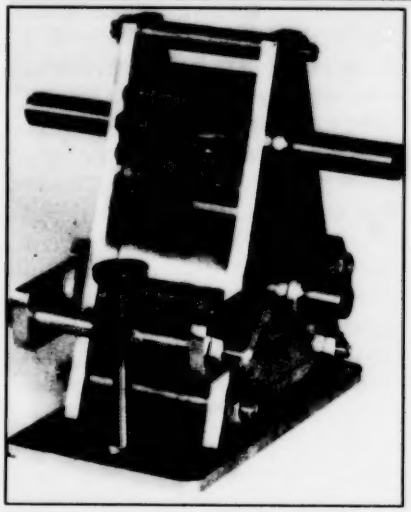
Goose wheat was obviously being produced around the turn of the century, since the Inspection and Sale Act of 1906 gave grade specifications for this class of wheat grown in Eastern Canada. The Canada Grain Act of 1912 included grade specifications for eastern grown Goose wheat and it remained in Schedule 2 of the Act until the May, 1939 amendment. Grade specifications for amber durum wheat were first included in the Act when it was revised in 1925.

It is interesting to note that the Manitoba Inspection Division inspected 1,065 bushels of Goose wheat in the year ending March 31, 1910 (Department of Trade and Commerce, 1911). In the Board of Grain Commissioners' Annual Reports, it is recorded that seven cars of Goose wheat were inspected in 1916 and eight cars in 1917. Durum wheat is first recorded in the year 1920 when 4,029 bushels were handled in terminal elevators. Actual production figures for durum wheat are difficult to ascertain, although production of this class began in Manitoba after the rust epidemic of 1916. Production eventually increased to the point where, in 1928, 56% of the wheat acreage in Manitoba was devoted to durum wheat (McRostie, 1934). According to the Grain Inspection Division records, durum wheat represented 3.77% of the wheat carlots inspected for that year.

The first mention of durum wheat in the Grain Research Laboratory (GRL) Annual Report is for the year 1927 when an "Investigation of the comparative keeping qualities of Marquis and durum wheat" was undertaken. The GRL was not equipped to carry out studies on durum wheat but in 1931 quality data for durum were reported for the first time. Only information on test weight, 1000 kernel weight and protein content was given with an explanation that "owing to lack of specialized apparatus, the laboratory was not in a position to prepare actual macaroni from the different grades and types of wheat." In 1932, samples of durum wheat grown on the experimental farm at Brandon were "investigated as to their value for the manufacture of macaroni." Tests performed were not specified.

Under Dr. F. J. Birchard, the first chief chemist (1913-1933), the annual protein survey of the newly-harvested durum wheat crop was started in 1932, five years after the initiation of the survey for red spring wheat. Quality evaluation work was not carried out at the GRL but was performed at the Manitoba Agricultural College.

The Associate Committee on Grain Research (founded in 1926 by the National Research Council), at its 10th meeting in November 1931, asked Dr. Geddes, Professor of Agricultural Chemistry at the Manitoba Agricultural College "to look into the question of what tests are required for the determination of quality in durum and what equipment it would be necessary to add to his laboratory to carry out such tests". Within the year, Dr. Geddes reported that most of the equipment for durum quality evaluation had been installed. The equipment included two stands of an Allis-Chalmers experimental mill, a small-scale purifier, an experimental macaroni unit comprising a mixer, kneader and a jacketed press (manufactured by a macaroni engineering firm in New Jersey), a Bausch and Lomb spectrophotometer and a quartz mercury lamp for carotene determination. A macaroni drying cabinet (4.11 meters long, 0.62 m wide and 1.60 m high) with humidity and temperature control was being constructed.



Kneader designed and built around 1946.

Macaroni drying cabinet in the 1940's.

Dr. W. F. Geddes was appointed the chemist-in-charge of the GRL in late 1933, and with him came the semolina milling and macaroni-making equipment in early 1934. The GRL was now equipped to carry out quality studies on durum wheat. Research projects initiated were: the effects of rusted, immature and starchy kernels on milling and macaroni quality, comparison of amber and red durum varieties, as well as the evaluation of the quality of the 1935 Standards and Averages. Interestingly, semolina yield ranged from 32% for No. 1 CWAD to 22% for No. 5 CWAD. In spite of such a low milling yield, it was reported that starchy kernels had no significant effect on semolina yield but semolina color was affected when starchy kernel content exceeded 30%.

The method for yellow pigment extraction was modified by using water-saturated n-butanol instead of naphtha. For measuring macaroni color, a color comparator using either Wallace and Tiernan or Munsell color discs was adopted. During Dr. Geddes' short term (1933-1938), a good foundation was laid for durum wheat research.

The next period from 1939 to 1962 under Dr. J. A. Anderson was, after the end of World War II, a period of expansion with hiring of more chemists and acquisition of new equipment. A major innovation immediately after the War was the design and construction of equipment for micro-processing of macaroni (Martin *et al*, 1946). This method was used for the next 25 years at the GRL. Also a new drying cabinet was designed, a unit that occupied far less floor space. Drying time was reduced from 60 to 48 hours. This drying cabinet, with slight modifications in humidity control, was used for the next 35 years. Drying time was, over the years, reduced to 22 hours.

The semolina milling procedure was

investigated in 1940 to try to increase milling yield from 32% to something approaching commercial yields. The break system was changed and yields in excess of 50% were attained. Essentially the same milling procedure was used for the next 20 years. In 1961 a study was begun to improve milling yield by incorporating a longer mill flow. Consequently, yield was increased to about 55%.

Immediately after the War, research on durum wheat centered on macaroni color and factors which affected color. The enzyme lipoxidase was identified as a factor in yellow pigment destruction during processing (Irvine and Anderson, 1949; Irvine and Winkler, 1950; Irvine *et al*, 1950). The kinetics of the lipoxidase system was investigated and the effects of inhibitors and temperature were reported (Irvine and Anderson, 1953). At this time, durum wheat varieties grown in Canada were those developed in the USA (Mindum, Stewart, Carleton, Nugget), an Algerian variety (Pelissier) and a South African variety (Golden Ball). The predominant varieties of the era, Mindum, Stewart and Pelissier, had low yellow pigment content. Thus, any loss of pigment during processing was a concern.

During the 23 years under Dr. Anderson, research at the GRL flourished, particularly in the field of dough rheology. And it was in the area of dough rheology that a significant contribution was made in assessing durum wheat gluten strength. A farinograph method for pasta doughs at pasta processing absorption around 30% was developed (Irvine *et al*, 1961). This made it possible to select strong gluten varieties in the durum wheat plant breeding program. Although plant breeders' varieties had been evaluated for quality since the mid-1930s, it was not until 1963 that the first variety developed in Canada was registered.

The next period from 1963 to 1978, under the direction of Dr. G. N. Irvine, was marked by further expansion, not only in the number of scientists and scientific support personnel, but also in equipment. Professional staff increased from 10 in 1962 to 15 by 1978, and total staff from 55 to 77. These were productive years with research in many areas of grain and oilseed chemistry and technology. Advances were made in processing technology, among them in semolina milling. A laboratory purifier for semolina was designed and built (Black, 1966) to replace the original small-scale purifier purchased in 1933. This was another step in increasing semolina yield to in excess of 60%. Continued modifications in the mill flow have led to the currently-achieved yields of around 65%.

In addition to the method for assessing gluten strength of durum varieties, an instrumental method for measuring the textural characteristics of cooked spaghetti was developed (Matsuo and

Pasta drying cabinet, 1950's.

Pasta processing laboratory, early 1950's.

Irvine, 1969, 1971). This was an important step in the plant breeding and variety improvement program. In 1969, the first variety with improved gluten strength, improved cooking quality and better color was registered. This was the variety Hercules, later to be named the statutory standard, replacing Mindum. Thereafter, in close collaboration with plant breeders, selections of the most promising varieties were made so that by 1978 four more varieties better than Hercules in overall quality were registered - Wascana in 1971, Wakooma in 1973, Macoun in 1974 and Coulter in 1977.

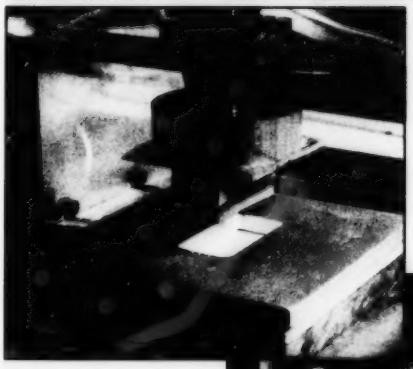
During the past 12 years, with acquisition of sophisticated instruments and microcomputers, the number of published research papers proliferated. Research on durum wheat, durum wheat products and processing technology kept pace. A laboratory-scale continuous extrusion press was used to study, among other topics, the changes in protein components during processing (Dexter and Matsuo, 1979) and changes in dough as observed with a scanning electron microscope (Matsuo *et al*, 1978). High temperature drying of pasta was investigated (Dexter *et al*, 1980) and several high temperature drying cycles were developed for the laboratory. An instrumental method for assessing surface stickiness of cooked spaghetti was devised using the GRL compression tester (Dexter *et al*, 1983).

The effect of some grading factors on pasta quality has been investigated - factors such as starchy, immature and shrunken kernels (Dexter and Matsuo, 1981), smudge, blackpoint, mildew and ergot (Dexter and Matsuo, 1982) and sprouted kernels (Matsuo *et al*, 1982; Dexter *et al*, 1990).

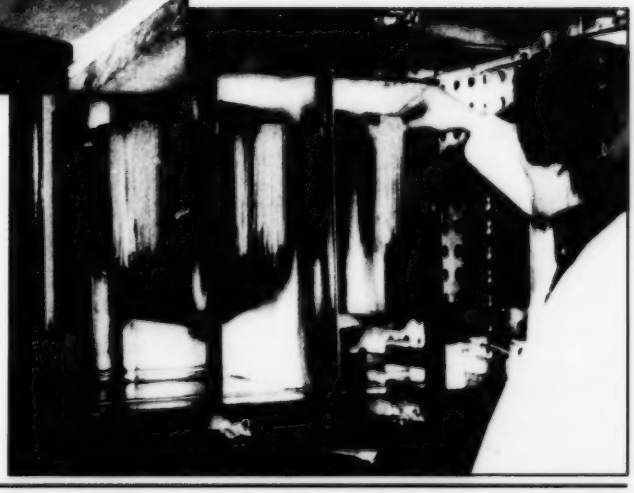
The development and/or modification of methods for quality evaluation of durum wheat and durum wheat products has enabled us to help plant breeders in selecting better varieties in durum wheat breeding programs. Since 1978 durum wheat varieties registered include Medora (1982), Arcola (1983), Kyle (1984), Sceptre (1985) and Plenty (1990). Amelioration of quality in Canadian amber durum wheat varieties is reflected in exports of Canada Western Amber Durum wheat.

The average export of durum wheat from 1940 to 1960 was 237,000 tonnes per year. In the next decade, this amount increased 2.7 fold to 645,000 tonnes/year, more than doubled again in the next decade (1971-1980) to 1,603,000 tonnes/year and from 1981-1989 rose to 2,172,000 tonnes/year. The dramatic increase in exports over the last 30 years (*see Figure 1*) can be attributed to both increasing pasta consumption and improvement in Canadian amber durum wheat varieties.

In quality monitoring and quality assurance, the GRL has maintained a program that has kept customers and potential customers of Canadian wheat informed of the quality characteristics of newly-harvested wheat and also of wheat exported during the crop year. The first report



GRL compression tester for measuring surface stickiness of cooked spaghetti.



Spaghetti drying cabinet currently in use.

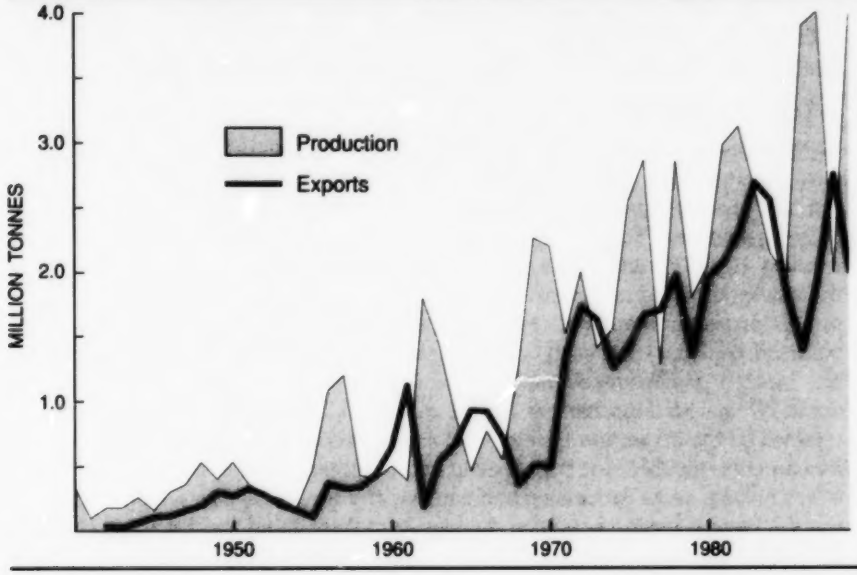


Figure 1. Annual production and exports of Canadian amber durum wheat - 1940 to 1989

on the quality of harvest survey amber durum wheat was released in 1936 and was a mimeograph copy made available to the trade. This format was continued until 1940.

In 1941 the first printed quality report was published as *"The quality of Western Canadian wheat: 1941 crop"*. Quality characteristics of the 1941 amber durum wheat crop were included but only information on durum flour for blending with bread flours was given. In the 1942 bulletin, quality characteristics of amber durum wheat, semolina and macaroni were included as part of the report. The form of the report has undergone a number of changes in the past 48 years but the primary intent, that of providing quality information to importers of Canadian wheat, has not changed.

As of August 1, 1957, the GRL started to publish a quarterly bulletin on the quality characteristics of amber durum wheat exported during each quarter of the crop year - similar in form and content to that for red spring wheat started on August 1, 1955. These bulletins have been very useful in recording the quality of wheat from quarter to quarter and from year to year. From August 1, 1983, durum bulletins have been published semi-annually.

During the 76 years in which the GRL has been operating, research on durum wheat has been ongoing for 56 years. In that period, 98 papers on durum wheat, durum wheat products and durum wheat processing have been published. The very first paper on durum wheat from the GRL was entitled *"Experimental durum milling and macaroni-making technique."* The GRL takes pride in having played a role in quality improvement of Canadian durum varieties and in contributing to the store of knowledge on what constitutes quality in durum wheat and how this quality can be assessed.

Appendix

Methods Used at the Grain Research Laboratory for Quality Evaluation of Durum Wheat and Durum Wheat Products

Sample Preparation

For quality evaluation tests to be meaningful, the samples selected for testing must be representative. For example, to represent an export cargo of No. 2 CWAD totalling 100,000 tonnes or to represent 1,000,000 tonnes of No. 1 CWAD of the newly harvested crop with a sample of 3 kg requires a statistically sound sample preparation method. For cargo sampling, about 20 kg of wheat is collected per hour from each belt during loading. As such a large sample from one cargo is unmanageable, sample size after thorough mixing is reduced to about 20 kg with a mechanical sample divider. A representative sample is retained by the Inspection Division and another representative portion is forwarded to the GRL for compositing into weighted grade average samples on which milling, pasta processing and cooking and analytical tests are performed. For the harvest survey, envelope samples from throughout the durum producing area in Western Canada are received from grain companies during the harvest period. Samples are selected to represent each crop district in proportion to Statistics Canada's estimate of production. About 3,000 samples are collected, graded and analyzed for protein content. They are then bulked together by grade to create the grade composite samples on which quality tests are done.

Wet Gluten

The wet gluten test is a very useful test that can provide a great deal of information to the experienced technologist. The amount gives a good indication of the protein content (weight of wet gluten divided by 2.5 equals approximate semolina protein content). Gluten strength can be judged by its extensibility and elasticity. Gluten color is an indication of pasta color as yellow pigment content is associated with gluten. Cohesiveness, or lack of it, can indicate damage (such as that caused by heat).

The determination of wet gluten content did not become one of the quality evaluation tests until 1956. A Theby gluten washing machine was used following Approved Method 38-11 of the AACC. Currently, the Glutamatic machine is used, according to ICC Standard Method No. 137.

SDS Sedimentation Test

As gluten quality is associated with good pasta quality, various methods for assessing gluten quality have been tried. One of the simplest and quickest is the sodium dodecyl sulfate (SDS) sedimentation test of Axford *et al* (1978). The sedimentation test measures the rate of hydration and the hydration capacity of gluten. The higher the sedimentation volume, the better the quality of gluten. The method as used at the GRL incorporates the modification of using a 3% solution of SDS instead of 2%.

Milling

Wheat is cleaned, scoured, tempered overnight to 16.5% moisture and milled using a modified Allis-Chalmers procedure. Following the third and fourth break passes, a sifter unit similar in design to that used for flour milling is used in place of the Allis-Chalmers box sifter. The box sifter is still used following the fourth sizing pass. The laboratory purifier was modified by installing a vibratory feed mechanism which maintains a uniform stream of stock going to the purifier and precisely regulates feed rate. Semolina yield averages 65% (clean wheat, constant moisture basis). The flow diagram is given in Figure 2.

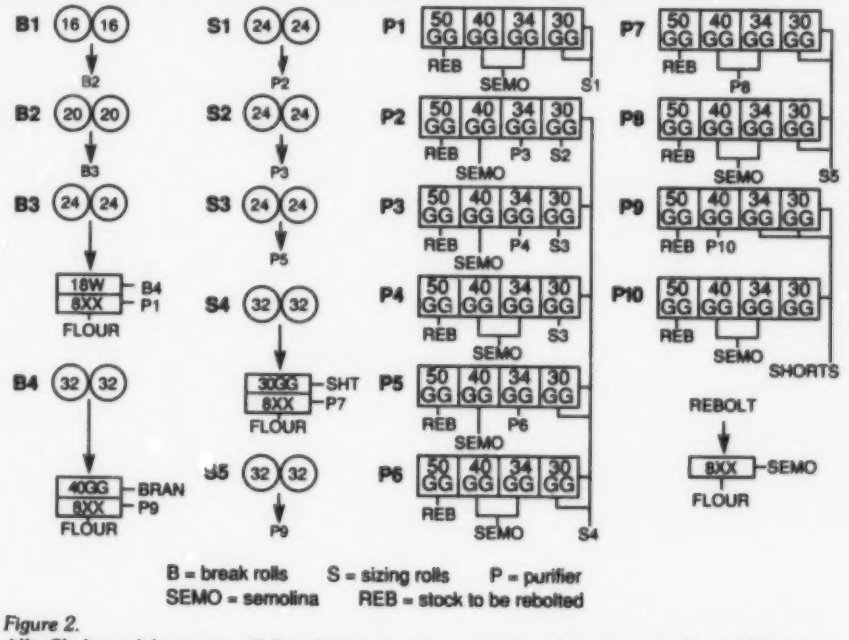


Figure 2.
Allis-Chalmers laboratory mill flow for durum wheat semolina. Sifters are modified GRL units.

Semolina Color

Color has always been an important factor in durum wheat quality. Yellow pigment extraction of both semolina and ground dried pasta by solvent extraction was one of the first tests set up for quality evaluation. This test continued to be used until the early 1980's. Semolina color is now determined with a reflectance color meter (Agtron), according to AACC Method No. 14-30. This method does not measure "yellowness" but "brightness".

Semolina Speck Count

Speckiness in semolina can result from the presence of damaged (discolored) kernels or foreign material in the grist or inefficient purification. Since a specky product is undesirable, one test for checking the efficiency of milling is the determination of the number of specks per unit area. There is no clear-cut definition of "speck" and differentiation must be made between bran specks and dark specks.

In the GRL method of speck count, a metal plate with a 25 cm^2 opening divided by a thin wire into quadrants is used. The semolina surface is smoothed with a spatula and the number of specks in each of the four quadrants is counted. A fresh semolina surface is prepared for each count. The count is replicated eight times. Results are reported as specks/50 cm^2.

Spaghetti Processing

Where a sufficiently large sample is available, spaghetti is processed on a laboratory-scale continuous process spaghetti press (Demaco S-25). For a normal run, 1.5 kg semolina is mixed in a Hobart C-100 mixer with a paddle blade at 26% absorption (14% moisture basis) for five minutes. The crumbly mixture is then transferred to the mixer of the Demaco. The first two-thirds of the extruded spaghetti is discarded and only one cut at this stage is taken for drying and subsequent testing. After each sample, the mixing chamber, the extrusion worm and the extrusion head is cleaned before the next sample is processed. Samples are dried at 70°C in a manner described by Dexter *et al* (1981).

In cases where sample size is limited, the micro-processing method is used (Matsuo *et al*, 1972). A 50-g sample of semolina is mixed in a farinograph bowl and sealed to allow mixing in a vacuum. After mixing, the dough is rested under pressure of 140 kg/cm^2 (2000 lb/in^2) for nine minutes, then extruded with a hydraulic press through a 4-hole teflon-lined spaghetti die.

Spaghetti Color

Whole strands of spaghetti are cut into lengths of about 4 cm and mounted on white cardboard for color measurements. Parameters obtained are brightness, a measure of the amount of light reflected from spaghetti surface relative to that reflected from a white surface, purity which is related to the hue and dominant wavelength, an indicator of "off-color" in spaghetti (576-577 nm = good yellow color; < 576 nm = lemon yellow, slightly greenish; > 577 nm = brownish). The Ten Selected Ordinates method is used for the derivation of the trichromatic coefficients. Readings taken on a Beckman DU-7 spectrophotometer with a reflectance attachment are fed into a microcomputer for computation of the color parameters.

Spaghetti Cooking Quality

The cooking characteristics of spaghetti are considered as very important quality factors. The hardness and pH of the cooking water, the ratio of water to dry pasta and the intensity of the boiling action all contribute to the textural characteristics. For the cooking test, approximately 5 g spaghetti, cut into lengths of about 5 cm, are boiled in 200 mL of tap water. Cooking time is taken as the time for the central white core to disappear, determined by squashing a strand between two clear plastic plates. Normal cooking time for spaghetti of diameter about 1.8 mm is 11 minutes.

The GRL tenderness tester is used to measure the shear rate (tenderness index, TI), resilience (R) and compressibility (C). A cooking quality parameter is

calculated as CQP = R/C x TI. The higher the value of CQP, the better is the cooking quality.

For assessing the surface characteristics of cooked spaghetti, standardized prepared water with mineral composition comparable to moderately hard water (pH of 7.5) is used for cooking. Stickiness is measured on a GRL compression tester as described by Dexter *et al* (1983). Cooking loss is determined by freeze-drying the cooking water and weighing the residue, correcting for the amount of salt in the prepared water.

Farinogram

The method described by Irvine *et al* (1961) is used for obtaining farinograms. Fifty grams of semolina (14% moisture basis) is mixed at 31.5% absorption in a 50-g stainless steel bowl with the 1:5 linkage setting. Parameters derived are: Dough Development Time (DDT) - the time required to reach maximum consistency; and Tolerance Index (TI) - the decrease in consistency in Brabender units (BU) from the peak to four minutes past the peak.

The shape of the mixing curve is influenced by the protein content, the type of gluten (whether strong or weak), absorption, temperature and particle size.

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Liaison Activities

Visitors to the Grain Research Laboratory

This year, 962 people visited the Grain Research Laboratory (GRL) - with tours ranging from short walk-throughs to lengthy, detailed technical demonstrations and discussions with GRL scientists and technologists. Of the total, 107 visitors were from the following 21 countries: Argentina, Australia, Ethiopia, Federal Republic of Germany, Finland, France, Holland, Hungary, India, Iran, Japan, Korea, Nepal, New Zealand, Pakistan, People's Republic of China, Philippines, Thailand, United Kingdom, USA, USSR. Not included in the foregoing list are countries represented by participants in Canadian International Grains Institute courses which incorporate tours of the GRL. Canadian visitors included: 283 grain producers, 60 elevator managers, 47 grain company representatives, 168 students in degree or diploma courses in agriculture at universities or community colleges and 5 persons involved with grain transportation.

Two holders of travelling fellowships from the Natural Sciences and Engineering Research Council of Canada completed their terms at the GRL this year: Dr. M. Edney joined the GRL staff as a research scientist in feed grains and Dr. M. Hidvegi returned home to Hungary. Two students working toward fulfilling requirements for the PhD degree at the University of Manitoba are undertaking research studies at the GRL: June Hu began a project in the oilseeds section and Linda Malcolmson continued her research in the durum wheat section. Yuji Yamada, a visiting scientist from the Yamazaki Baking Company in Japan, is performing oxidation studies in breadmaking with Dr. K. Preston. Dr. E.A. MacGregor, on sabbatical from the University of Manitoba, completed work in the basic barley research section on various aspects of starch and beta-glucan degrading enzymes.

Grain Research Laboratory staff volunteer annually to take part in charity fundraising activities of the United Way Campaign of Winnipeg. This year, the Canadian Grain Commission organized a successful luncheon barbecue as a kick-off event in which GRL staff members participated as cooks, servers, cashiers and consumers.

A visit being paid to the Analytical Services section of the GRL by persons enrolled in Agricultural Marketing at the Saskatchewan Institute of Applied Science and Technology.

The chef attentively serving another eager customer.

The end results of the chef's efforts appear to be very satisfactory.

United Way Barbecue

Committee Membership

Canadian Grain Commission
- Eastern and Western Grain Standards Committees ..... K.H. Tipples

Agriculture Canada
- Advisory Committee on Variety Registration ..... R.R. Matsuo
- Expert Committee on Fats, Oils and Other Lipids ..... J.K. Daun
- Inter-Branch Working Group on Fumigants ..... T.W. Nowicki
- Western Expert Committee on Grain ..... K.H. Tipples
- Prairie Registration Recommending Committee for Grain
  - Evaluation Team, Barley and Oats ..... D.E. LaBerge *(chairman)*
    A.W. MacGregor
    - Ad Hoc Subcommittee on Oats ..... A.W. MacGregor
  - Evaluation Team, Oilseeds ..... J.K.Daun *(chairman)*
    D.R. DeClercq
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  - Evaluation Team, Wheat, Rye and Triticale ..... K.R. Preston *(chairman)*
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Agricultural Institute of Canada
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  - Bread Baking Methods ..... K.R. Preston
  - Experimental Milling ..... J.E. Dexter *(chairman)*
  - Methods for Grain Testing ..... P.C. Williams
  - Near-infrared Reflectance ..... P.C. Williams
  - Oat Bran ..... P.C. Williams
  - Pasta Products Analysis ..... J.E. Dexter
    R.R. Matsuo
  - Physical Testing Methods ..... K.R. Preston
  - Quality Tests for Wheat and Flour ..... R. Tkachuk
  - Total Dietary Fiber ..... P.C. Williams
  - Yeast Evaluation ..... P.C. Williams
- Canadian Prairie Section ..... V.J. Mellish *(president)*
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- Commercial Fats and Oils Analysis Committee ..... J.K. Daun
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Brewing and Malting Barley Research Institute
- Technical Committee ..... D.E. LaBerge

Canadian General Standards Boards
- Committee on Bakery and Cereal Products ..... R.R. Matsuo

Codex Alimentarius Commission, FAO/WHO
- Canadian Delegation ..... R. Tkachuk *(chairman)*

European Brewing Convention Barley and Malt Group
- Barley Quality Assessment Subgroup ..... A.W. MacGregor

Federal Interdepartmental Committee on Pesticides Check Sample Program
- Feeds/Grains Sub-program ..... T.W. Nowicki *(coordinator)*

Flax Council of Canada
- Market Development Committee ..... J.K. Daun
- Research and Technical Committee ..... J.K. Daun

Group consultatif international pour la recherche sur la colza ..... J.K. Daun

International Association for Cereal Science and Technology (ICC)
- Executive Committee, Technical Committee and General Assembly ..... K.H. Tipples
- Working Groups on:
  - Variety Identification by Electrophoresis ..... R. Tkachuk
  - Baking ..... K.H. Tipples *(chairman)*
  - Determination of Wet Gluten ..... K.R. Preston
    P.C. Williams
  - Particle Size/Wheat Hardness ..... P.C. Williams
  - Methods of Protein Determination ..... R. Tkachuk
  - Sampling ..... P.C. Williams
  - Near-infrared Technology ..... P.C. Williams

International Committee on Pre-Harvest Sprouting ..... J.E. Kruger

International Gluten Workshop (1990)
- Organizing Committee ..... R. Tkachuk *(chairman)*

International Rapeseed Congress (1992)
- Program Committee ..... J.K. Daun

International Standards Organization	
Canadian Advisory Committee TC34/SC4	K.H. Tipples *(chairman)*
	R.Tkachuk
Canadian Advisory Committee TC34/SC2	J.K. Daun
Canadian Advisory Committee TC34/SC11	J.K. Daun
Journal of Cereal Science	
Board of Editors	K.H. Tipples
Journal of the Institute of Brewing	
Editorial Board	A.W. MacGregor
Manitoba Sunflower Committee	J.K. Daun
Master Brewers' Association of the Americas	
Housing Committee for 1992 Convention	D.E. LaBerge *(chairman)*
Red River Community College	
Advisory Committee for Chemical and Biochemical Technology	R. Tkachuk
	D.E. LaBerge
University of Guelph	
Adjunct Professor	P.C. Williams
University of Manitoba	
Adjunct Professors, Department of Plant Science	J.K. Daun
	J.E. Kruger
	A.W. MacGregor
	R.R. Matsuo
	R. Tkachuk
	P.C. Williams
Western Canada Pesticide Residue Analysts	
Organizing Committee - 1989 Workshop	T.W. Nowicki
Winnipeg Brewmasters Association	D.E. LaBerge *(chairman)*

Conference and Meeting Attendance

Agriculture Canada

Advisory Committee on Variety Registration
Meeting in Ottawa, ON ..... R.R. Matsuo

Expert Committee on Fats, Oils and Other Lipids
1989 Meeting, Halifax, NS ..... J.K. Daun

Western Expert Committee on Grain
1990 Meeting, Winnipeg, MB ..... K.H. Tipples

Prairie Registration Recommending Committee for Grain
1990 Meeting, Winnipeg, MB ..... J.K. Daun
D.E. LaBerge
A.W. MacGregor
R.R. Matsuo
K.R. Preston
R. Tkachuk
P.C. Williams

Eastern Expert Committee on Grain
1990 Meeting, Montreal, QC ..... T.W. Nowicki

Western Computers Users Meeting
Summerland, BC ..... R. Tkachuk

American Association of Cereal Chemists

Annual Meeting, Washington, DC ..... J.E. Dexter
J.E. Kruger
B.C. Morgan
S.J. Symons
K.H. Tipples
R. Tkachuk
P.C. Williams

Milling and Baking Technical Conference
Minneapolis, MN ..... E.J. Gander
R. Tkachuk

Short Course on Milling
Manhattan, KS ..... G. Holowka

Short Course on Moulds and Mycotoxins
Lincoln, NE ..... R.M. Clear

American Oil Chemists' Society

Annual Conference, Cincinnati, OH ..... J.K. Daun
J.A. Panford

Briefing - 1992 Conference, Champaign, IL ..... J.K. Daun

Canadian Section Meeting, Halifax, NS ..... J.K. Daun

Seed and Meal Analysis Committee
Meeting in Chicago, IL ..... J.K. Daun

American Society of Brewing Chemists

Annual Meeting, Denver, CO ..... A.W. MacGregor

Association of Official Analytical Chemists
Annual Meeting, St. Louis, MO ..... T.W. Nowicki
Mid-Canada Regional Section Meeting
Winnipeg, MB ..... D.G. Gaba
T.W. Nowicki
J.W. Thorsteinson

Association of Official Seed Analysts
Annual Meeting, Peoria, IL ..... K.E. Bell

Association of Operative Millers
Annual Conference, Seattle, WA ..... R.G. Desjardins
District #8 Meeting, Niagara Falls, ON ..... K.R. Preston

Canadian Phytopathological Society
Local Conference, Winnipeg, MB ..... R.M. Clear

Canola Industry Conference
Saskatoon, SK ..... D.R. DeClercq

Crop Quality Council
Annual Meeting, Kansas City, MO ..... K.R. Preston

Eastern Grain Standards Committee
1989 Meeting, Toronto, ON ..... K.H. Tipples

Eurolipid Congress International "Chevreul"
Angers, France ..... J.K. Daun

European Brewery Convention
Congress, Zurich, Switzerland ..... D.E. LaBerge

FAO/IDRC/IARC
Symposium on Future of Utilization of Grains in Developing Countries
Rome, Italy ..... P.C. Williams

Forum on Pests of Stored Grain Products
Winnipeg, MB ..... T.W. Nowicki

Grain Elevator and Processing Society
Local Meeting, Thunder Bay, ON ..... K.H. Tipples

Hazardous Waste Management Conference
Edmonton, AB ..... N.H. Barchuk

Industrial Accident Prevention Association
Safety Conference, Toronto, ON ..... N.H. Barchuk

International Association for Cereal Science and Technology (ICC)
- Executive Committee Meeting, Lahti, Finland ..... K.H. Tipples
- 1989 Symposium, Lahti, Finland ..... J.E. Dexter, K.R. Preston, K.H. Tipples, P.C. Williams

International Baking Exposition
- Las Vegas, NV ..... F.G. Paulley, K.R. Preston

International Standards Association
- Canadian Advisory Committee Meeting
  - Ottawa, ON ..... K.H. Tipples
- TC34/SC2 Committee Meeting, Angers, France ..... J.K. Daun
- TC34/SC11 Committee Meeting, Angers, France ..... J.K. Daun

International Symposium on Pre-Harvest Sprouting
- Loen, Norway ..... J.E. Kruger

International Wheat Gluten Association
- Meeting in Banff, AB ..... J.E. Dexter

Institute of Brewing
- Local Meeting, Brisbane, Australia ..... A.W. MacGregor

Institute of Food Technologists
- Annual Conference, Chicago, IL ..... T.W. Nowicki

Manitoba Agri-Forum
- Winnipeg, MB ..... L.A. Cooke, T.W. Nowicki

Manitoba Sunflower Committee
- Annual Tour ..... K.M. Clear

Master Brewers' Association of the Americas
- District Western Canada Annual Convention
  - Vancouver, BC ..... D.E. LaBerge

Red River Barley Days
- East Grand Forks, MN ..... D.E. LaBerge

Royal Australian Chemical Institute
- Conference in Perth, Australia ..... A.W. MacGregor, P.C. Williams

Royal Chemical Institute of Sweden	
Annual Conference, Gothenburg, Sweden	P.C. Williams
Scanning Electron Microscopy, Inc	
Annual Meeting, Salt Lake City, UT	A.W. MacGregor
Spring Wheat Quality Advisory Council	
Annual Meeting, Fargo, ND	R.R. Matsuo
	B.C. Morgan
	E. Mydlo
Statistical Association of Manitoba	
Annual Meeting, Winnipeg, MB	J.C. Babb
Statistical Society of Canada	
Annual Meeting, Ottawa, ON	J.C. Babb
Symposium on Utilization of Genetic Resources in Plant Breeding	
ICARDA, Aleppo, Syria	P.C. Williams
Triennial Barley Improvement Conference	
Lethbridge, AB	A.W. MacGregor
	B.A. Marchylo
Unscrambler Users Association	
Conference in Copenhagen, Denmark	P.C. Williams
Western Canada Pesticide Residue Analysts	
Annual Meeting, Winnipeg, MB	T.W. Nowicki *(chairman)*
	D.G. Gaba
	W.H. Harnden
	A.W. Holmberg
	J.W. Thorsteinson
Western Committee on Crop Pests	
Annual Meeting, Winnipeg, MB	T.W. Nowicki
Western Grain Standards Committee	
1989 Meeting, Winnipeg, MB	K.H. Tipples
Workshop on Near-infrared Spectroscopy	
Food Research Institute, As, Norway	P.C. Williams
Workshop on Near-infrared Technology	
Wagga Wagga, Australia	P.C. Williams
Winona Workshop on Professional Photography	
Chicago, IL	H. Zimberg

Oral Presentations

At Canadian International Grains Institute

K.H. Tipples
- Introduction to the Grain Research Laboratory *(presented three times)*
- Laboratoire de recherches sur les grains
- Research at the Grain Research Laboratory

J.K. Daun
- Effects of Degrading Factors on End-use Quality of Canadian Oilseeds
- Oilseed Grading Factors and Related End-use Product Quality
- Oilseed Processing and Effects of Degrading Factors on Oilseeds Utilization

D.R. DeClercq and K.M. Clear
- Oilseed Quality Analysis Techniques *(presented three times)*

J.E. Dexter
- Canadian Wheat Quality: Milling and Baking Characteristics
- Effects of Grading Factors on End-use Quality of Canadian Wheat
- End-use Quality Implications and the Canadian Grading System *(presented twice)*
- Wheat Quality: A Complex Subject

J.E. Kruger
- Introduction to the Grain Research Laboratory

D.E. LaBerge
- Barley Research and Quality Control at the GRL
- Effects of Grading Factors on End-use Quality of Malting Barley
- Introduction to the Grain Research Laboratory
- Malting Barley in Western Canada

A.W. MacGregor
- Barley Beta-glucan
- Biochemistry of Malting
- Effects of Degrading Factors on Barley Utilization
- Recent Research in Malting

A.W. MacGregor and L.G. Dushnicky
- Electron Microscopy

D.G. Martin
- Milling Technology

B.A. Marchylo
- The GRL Pilot Malting Plant *(presented four times)*

R.R. Matsuo
- Effects of Degrading Factors on Durum Wheat Utilization
- Measurement of Pasta Quality
- Pasta Goods Manufacturing *(presented six times)*
- Wheat: Properties, Functionality and End-uses
- Wheat Quality Research at the GRL

V.J. Mellish and D.W. Hatcher
- Varietal Purity Control

L.J. Morris
- Measurement of Sprout Damage

J.A. Panford
- Measurement of Protein and Moisture Using NIRS
- Utilizing NIRS Technology

K.R. Preston
- Baking Research at the GRL

K.R. Preston and B.C. Morgan
- Baking Technology

S.J. Symons
- Image Analysis

P.C. Williams
- Analytical Methodology at the GRL
- Effects of Degrading Factors on Spring and Winter Wheat Utilization

At Conferences, Meetings and Seminars

K.H. Tipples
- Changing Quality Requirements for Canadian Grain
  Grain Elevator and Processing Society Meeting, Thunder Bay, ON
- Grain Quality From a Canadian Perspective
  AACC, Annual Meeting, Washington, DC
- Physical and Chemical Properties of Wheat as a Basis for Determination of End-use Quality
  ICC Symposium, Lahti, Finland

J.C. Babb
- Statistical Consulting at the GRL
  University of Alberta, Edmonton, AB
- The Role of a Statistical Consultant
  University of Manitoba, Winnipeg, MB
- Analysis of Variance and Experimental Design
  Lecture Series at the GRL, Winnipeg, MB

N.H. Barchuk

Explanation of Workplace Hazardous Materials Information System - WHMIS *(presented four times)*
Grain Research Laboratory, Winnipeg, MB

R.M. Clear

Biohazardous Substances
WHMIS Lecture, GRL, Winnipeg, MB

J.K. Daun

Image Analysis as a Tool for Investigating Seed Size Relationships in Canola
AOCS, Canadian Section Meeting, Halifax, NS
Studies on the Determination of Chlorophyll in Canola by HPLC,
Modified NIR Reflectance and Extraction and Spectrophotometry
Eurolipid Congress International "Chevreul", Angers, France
Vaccenic Acid as a Major Component of the Triglycerols in Residual Oils of Canola Meals
AOCS, Annual Meeting, Cincinnati, OH
Compressed Gases
WHMIS Lecture, GRL, Winnipeg, MB

D.R. DeClercq

Quality of Western Canadian Canola 1989
Canola Industry Meeting, Saskatoon, SK
Flammable Substances
WHMIS Lecture, GRL, Winnipeg, MB

D.R. DeClercq and T.W. Nowicki

Labelling of Controlled Substances
WHMIS Lecture, GRL, Winnipeg, MB

J.E. Dexter

Milling Efficiency: The Relevance of Flour Ash Content and Flour Color and
the Potential Application of Near-infrared Spectroscopy and Fluorescence Imaging
ICC Symposium, Lahti, Finland
The Pasta Making Quality of Commercial Durum Wheat Samples of Variable Alpha-amylase Activity
AACC, Annual Meeting, Washington, DC
Recent Milling Research at the GRL
RHM Research Center, High Wycombe, England
Wheat Quality from a Canadian Perspective
International Wheat Gluten Association Meeting, Banff, AB

D.G. Gaba

Mycotoxins: A Canadian Grain Commission Perspective
Grain Research Laboratory Seminar, Winnipeg, MB

J.E. Kruger

Quantitative Analyses by RP-HPLC of Storage Protein Breakdown in Canadian Wheat Upon Germination
Monitoring for Sprout Damage and Its Implications for End-product Quality in Cereals
International Symposium on Pre-harvest Sprouting, Loen, Norway
Rapid Monitoring of Sprout Damage in Wheat at Terminal Receival Points
AACC, Annual Meeting, Washington, DC
Sprout Damage and the Need for Careful Grain Segregation
Grain Terminals, Vancouver, BC and Thunder Bay, ON

A.W. MacGregor

Studies on (1,3)-Beta-glucan in Barley Endosperm
SEM Inc, Annual Meeting, Salt Lake City, UT
Identification and Properties of a Beta-glucan Solubilase from Barley Kernels
ASBC, Annual Meeting, Denver, CO
Beta-glucan Solubilase: Fact or Fiction?
La Trobe University, Melbourne, Australia
Changes in the Structure and Composition of Barley Kernels During Development
Properties of Alpha-amylases from Malted Barley
Royal Australian Chemical Institute, Conference in Perth Australia
Cereal Alpha-amylases: Location and Properties
Wheat Research Institute, North Ryde, Australia
Malting Barley Research in Canada *(presented twice)*
Institute of Brewing, Section Meetings in Melbourne and Brisbane, Australia
The Chemistry and Biochemistry of Malting
The Structure of Cereal Grains
MBAA, Short Course, Madison, WI

L.J. Macri

Acute and Chronic Hazards of Toxic Substances
WHMIS Lecture, GRL, Winnipeg, MB

T.W. Nowicki

Important Food Safety Issues Affecting Grain
IFT, Annual Meeting, Chicago, IL
Food Quality and Chemical Residues in Grain
Manitoba Agri-Forum, Winnipeg, MB
CGC Activities Related to Fusarium Mycotoxins in Eastern Canadian Grains
Eastern Expert Committee on Grain, Montreal, QC
Management of Dangerous Substances: Pesticides
Grain Research Laboratory Seminar, Winnipeg, MB

K.R. Preston

Quality of the 1989 Canadian Wheat Crop
AOM, District Meeting, Niagara Falls, ON

R. Tkachuk

Specific Gravity Fractionation of Wheat
AACC, Milling and Baking Conference, Minneapolis, MN
Radioactive Substances
Cryogenic Substances
WHMIS Lectures, GRL, Winnipeg, MB

P.C. Williams

New Applications of Near-infrared Technology
Utilization of Durum Wheat in the Middle East
ICC Symposium, Lahti, Finland
Studies on the Quality of Crosses Involving *T. dicoccoides* in Durum Wheat Breeding
ICARDA Symposium, Aleppo, Syria
Technique of Application of Near-infrared Technology
NIRS Workshop, Norwegian Food Research Institute, As, Norway
Principles of Near-infrared Technology
Application of Near-infrared Technology to the Analysis of Wheat
Royal Chemical Institute of Sweden, Annual Conference, Gothenburg, Sweden
Recent Innovations in Near-infrared Technology
Factors Affecting the Quality of Two-layered Arabic Bread
Quality Parameters in Food Legume Evaluation
Royal Australian Chemical Institute, Annual Conference, Perth, Australia
Near-infrared Technology in the Grain and Seed Industries
Workshop on NIRS, Wagga Wagga, Australia
Relation of Chemical Analysis of Grains and Seeds to Functionality
FAO/IDRC/IARC Symposium, Rome, Italy
Calibration Practice for Near-infrared Instruments
Unscrambler Users Assoc. Conference, Copenhagen, Denmark
Determination of Moisture in High Moisture Corn by Near-infrared Transmittance
Influence of Temperature on Absorbance Bands of Water
AACC, Annual Conference, Washington, DC
Handling, Storage and Disposal of Corrosive Chemicals
WHMIS Lecture, GRL, Winnipeg, MB

Publications

Scientific Papers

613 LUKOW, O.M., PAYNE, P.I., TKACHUK, R.
The HMW Glutenin Subunit Composition of Canadian Wheat Cultivars and Their Association With Bread Making Quality.
J. Sci. Food Agric. 46:451-460, 1989.

620 YIN, X.S., MACGREGOR, A.W.
Substrate Specificity and Nature of Action of Barley Beta-glucan Solubilase.
J. Inst. Brew. 95:105-109, 1989.

621 YIN, X.S., MACGREGOR, A.W., CLEAR, R.M.
Field Fungi and Beta-glucan Solubilase in Barley Kernels.
J. Inst. Brew. 95:195-198, 1989.

624 MARCHYLO, B.A., KRUGER, J.E., HATCHER, D.W.
Quantitative Reversed-phase High Performance Liquid Chromatographic Analysis of Wheat Storage Proteins as a Potential Quality Prediction Tool.
J. Cereal Sci. 9:113-130, 1989.

625 PRESTON, K.R., MORGAN, B.C., KILBORN, R.H., TIPPLES, K.H.
Assessment of Heat Damage in Canadian Hard Red Spring Wheats.
Can. Inst. Food Sci. Tech. J. 22(1):63-69, 1989.

626 DECLERCQ, D.R., DAUN, J.K.
Determination of the Total Glucosinolate Content in Canola by Reaction with Thymol and Sulfuric Acid.
J. AOCS 66(6):788-791, 1989.

627 MARCHYLO, B.A., HANDEL, K.A., MELLISH, V.J.
Fast Horizontal SDS Gradient Polyacrylamide Gel Electrophoresis for Rapid Wheat Cultivar Identification and Analysis of High Molecular Weight Glutenin Subunits.
Cereal Chem. 66(3):186-192, 1989.

628 PRESTON, K.R.
Effects of Neutral Salts of the Lyotropic Series on the Physical Dough Properties of a Canadian Red Spring Wheat Flour.
Cereal Chem. 66(3):144-148, 1989.

629 DEXTER, J.E., MARCHYLO, B.A., MACGREGOR, A.W., TKACHUK, R.
The Structure and Protein Composition of Vitreous, Piebald and Starchy Durum Wheat Kernels.
J. Cereal Sci. 10:19-32, 1989.

631 DEXTER, J.E., MATSUO, R.R., DANIEL, R.W.
The Influence of Heat Damage on Durum Wheat Spaghetti Quality.
Can. Inst. Food Sci. Tech. J. 22(3):227-237, 1989.

632 MACGREGOR, A.W., DUSHNICKY, L.G.
Starch Degradation in Endosperms of Developing Barley Kernels.
J. Inst. Brew. 95:321-325, 1989.

633 PANFORD, J.A.
Analysis of Oilseeds for Protein and Oil by Near-infrared Reflectance Spectroscopy.
In: *Methods for Protein Analysis*, Chap.1:1-12, published by J. AOCS, 1988.

635 DAUN, J.K., THORSTEINSON, C.T.
Determination of Chlorophyll Pigments in Crude and Degummed Canola Oils by HPLC and Spectrophotometry.
J. AOCS 66(8):1124-1128, 1989.

636 DEXTER, J.E., KILBORN, R.H., PRESTON, K.R.
The Baking Performance of Canadian Bread Wheat Classes Using a Colombian High-fat High-sugar Short Process.
Can Inst. Food Sci. Tech. J. 22(4):364-371, 1989.

637 MACGREGOR, A.W., BALLANCE, G.M., DUSHNICKY, L.G.
Fluorescence Microscopy Studies on (1,3)-Beta-glucan in Barley Endosperm.
Food Microstructure 8:235-244, 1989.

638 KILBORN, R.H., KRUGER, J.E., TIPPLES, K.H.
The GRL Paste Viscosity Indicator for Rapid Determination of Alpha-amylase in Canadian Red Spring Wheat.
Can. J. Plant Sci. 69:1093-1100, 1989.

641 CLEAR, R.M., NOWICKI, T.W., DAUN, J.K.
Soybean Seed Discoloration by *Alternaria* Spp. and *Fusarium* Spp.: Effects on Quality and Production of Fusariotoxins.
Can. J. Plant Path. 11:308-312, 1989.

Miscellaneous Papers

M153 MARCHYLO, B.A., MELLISH, V.J.
Identification of Canadian Wheat Cultivars by SDS Gradient PAGE and RP-HPLC Analysis of Gliadins and Glutenins.
Proc., Third Int. Sym. on Biochem. Ident. of Varieties

Other Publications

MCGREGOR, J.R., BABB, J.C.
Serially Correlated Differences in the Paired Comparison of Time Series.
Biometrika 76(4):735-739, 1989.

MARK, H., NORRIS, K.H., WILLIAMS, P.C.
Methods of Determining the True Accuracy of Analytical Methods.
Analytical Chemistry 61:398-403, 1989.

Periodicals

Sixty-second Annual Report. 1988-89 Report of the Grain Research Laboratory

Cargo Bulletins

Red spring wheat editions are published in an English-French-German-Spanish version and an English-Chinese Version (suffix"C").
Amber durum wheat editions are published in an English-French-German-Italian version.

248 Quality of Canadian Grain Exports 1988-89, Red Spring Wheat, second quarter, (Nov. 1 to Jan. 31)

249 Quality of Canadian Grain Exports 1988-89, Amber Durum Wheat, first and second quarters (Aug. 1 to Jan. 31)

250 Quality of Canadian Grain Exports 1988-89, Red Spring Wheat, third quarter (Feb. 1 to Apr. 30)

251 Quality of Canadian Grain Exports 1988-89, Red Spring Wheat, fourth quarter (May 1 to July 31)

252 Quality of Canadian Grain Exports 1988-89, Amber Durum Wheat, third and fourth quarters (Feb. 1 to July 31)

253 Quality of Canadian Canola and Flaxseed Cargoes, 1988-89 Crop Year

254 Quality of Canadian Grain Exports 1989-90, Red Spring Wheat, first quarter (Aug. 1 to Oct. 31)

Crop Bulletins

178 Quality of Western Canadian Wheat 1989

179 Quality of Western Canadian Feed Barley 1989

180 Quality of Western Canadian Malting Barley 1989

181 Quality of Western Canadian Canola 1989

182 Quality of Western Canadian Flaxseed 1989

183 Quality of Canadian Soybean 1989

Staff

K.H. Tipples, *BSc, PhD*	Director
N.H. Barchuk, *BSc*	Special Assistant to the Director *(Research)*
R.H. Kilborn	Research Baking Advisor
C.R. Bunston, D.J. Ramsay*	Secretaries

Administration

N.L. Morgan	Assistant Director *(Administration)*
K.A. Tait	Office Manager
E.F. Anderson, M.C. Cyr*, G.A. McLean, A.M. Robertson*	Clerks
S.L. Wiebe	Word Processing
M.E. Lick, *Dipl AA*	Secretary
A.R. Duda, M.L. Magill*, G.M. Stein, C.C. Wereschuk	Casual Assistants

Analytical Development and Services

P.C. Williams, *BSc, PhD*	Research Scientist
J.A. Panford, *BSA, MSc, PhD*	Chemist
L.J. Morris	Senior Technologist
C.J. Ashley, H.M. Cordeiro, *Dipl T*, F.Y. Lim, L.G. Oneschuk, C.M. Panting, D.C. Sobering, *BSc*, R.K. Brady, D.L. Parent, *Dipl T*, T. Boomer, *BSc*, T. Harnden, *BSc*, D. Heide, G.R. Hennessey, D.S. Saydak, *BSA*, J.P. Yau, *BSc, MSc*	Scientific Support
S. Stevenson, S. Harborne	Casual Assistants

Basic Barley Research

A.W. MacGregor, *BSc, PhD*	Research Scientist
M. Edney, *BSc, MSc, PhD*	Research Scientist
J.E. Morgan, *BSc*	Chemist
L.G. Dushnicky, *BSc*	Senior Technologist
S.W. Schroeder, *BSc*	Scientific Support
S. Deleau**, W. Klassen	Casual Assistants

Breadwheat Studies and Baking Research

K.R. Preston, *BSc, MSc, PhD*	Research Scientist
B.C. Morgan, *BSc*	Chemist
E.J. Gander, E. Mydlo, F.G. Paulley, G.T. Kawamoto, *BSc (Agric)*, L.W. Minty, E.D. Lysenko, *BPE*, L.H. Pelletier, *BSA*, I.H. Phillips, *BSc*, C.K. Taplin	Scientific Support
D. Pereira**, C. Varnes	Casual Assistants

Cereal Protein Research

B.A. Marchylo, *BSc, MSc, PhD*	Research Scientist
K.A. Handel*, *Dipl T*, P.A. Funk, *Dipl T*, G.A. Steidl, *BSc*	Scientific Support
M. Nightingale, C. Smith**	Casual Assistants

Grain Biology and Malting Barley Applied Research

D.E. LaBerge, *BSc, MSc, PhD*	Research Scientist
S.J. Symons, *BSc, PhD, CBiol, MIBiol*	Research Scientist
R.M. Clear, *BSA, MSc*	Mycologist
L.A. Cooke, *ASA, BSA*	Biologist
D.E. Langrell, *BSc*, A.D. Mitchelson, K.E. Bell, *ASA, BSc*, C. Butler, B.M. Moody, *ASA*, M.M. Stethem, N. Vidal*, J.R. Bethune, S.K. Patrick, *BSc*,	Scientific Support

Laboratory Milling and Research

J.E. Dexter, *BSc, MSc, PhD*	Research Scientist
D.G. Martin	Senior Technologist
N.M. Edwards, *Dipl T, BSc*, J.J. Lachance, R.G. Desjardins, W. Aarts, G. Holowka, *BA*, D.R. Ouellette, J.N. Burrows, *BSA*	Scientific Support
G. Shimizu**, J.A. Spicer	Casual Assistants

Oilseeds Research

J.K. Daun, *BSc, MSc, PhD, MCIC*	Research Scientist
D.R. DeClercq, *BSc*, C.T. Thorsteinson, *BSc*	Chemists
P.B. Mazur, K.M. Clear, *BSA*, H.K. Howard, B.A. Misener	Scientific Support
K. Dashensky*, A. Frank**, B. Ng	Casual Assistants

Publications and Durum Wheat Research

R.R. Matsuo, *BSc, PhD, MCIC*	Research Scientist
J.C. Babb, *BSc, MSc*	Biometrician
P.R. March, *BSc*	Information Services
R.W. Daniel	Senior Technologist
A.R. Armstrong, H. Zimberg, D.M. Chance, *BID*, M. Lymych, S.M. Beauchemin, *Dipl AdA*, C.A. Rebizant, K.A. Zaborniak	Scientific Support

Residue Analysis

T.W. Nowicki, *BSc*	Chemist
D.G. Gaba, *BSc*	Chemist
J.W. Thorsteinson, *Dipl T*, W.H. Harnden, *BSA*, A.M. Holmberg, *BSA*	Scientific Support

Wheat Chemistry and Laboratory Services

R. Tkachuk, *BA, MSc, PhD, FCIC*	Research Scientist
L.J. Macri, *BSc, MSc*	Chemist
H.E. Hughes	Senior Technologist
S. Lowe, *BSc*, R.J. Wallis, *Dipl T*, G.G. Baker, J. Kopilas, *BSA*	Scientific Support
M. Kennedy**	Casual Assistant

Wheat Enzyme Research

J.E. Kruger, *BSc, MSc, PhD, MCIC*	Research Scientist
D.W. Hatcher, *BSc, MSc*	Chemist
D.A. Daniel, *Dipl T*, S.L.Sigurdson, *Dipl T*, H. Facto	Scientific Support
J.Bernardin, G. Harland*, G. Kapoor*, G. McRae**, S. Moffat, T. Pawlinsky, R. Roscoe*	Casual Assistants

Wheat Varietal Identification

V.J. Mellish, *BSc*	Chemist
S.E. Gowan, *Dipl T*, G.G. Bell, *Dipl T*, K. Jarrin	Scientific Support

* Separated from staff during this reporting period.
** Career-oriented Summer Employment Program (COSEP).